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SOME EXPERIMENTS IN THE HYBRIDISING OF INDIAN COTTONS

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SOME EXPERIMENTS IN THE HYBRIDISING OF INDIAN COTTONS.

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Experiments in crossing different varieties of cotton plants have often been made with the idea of uniting into one, the good qualities of two or more strains. Some reference to these may be found in Sir George Watt's book, "The wild and cultivated cotton plants of the world." The first experiments of which records have been made, were, he says,* perhaps those by Rohr, who more than a hundred years ago crossed some American fuzzy and clean seeded species, but did not apparently experiment with Indian cottons. In 1884, however, Dr. Alexander Burns of Broach crossed *Gossypium obtusifolium* var. *wightiana* [Guzerat cotton] with the red flowered *G. arboreum*, and obtained a plant having the good qualities of both parents. "The leaves were those of Arboreum, ...the flowers were red with a yellow throat" and the plant cropped early and produced a very silky floss. But nothing seems to be known about the subsequent history of this cross and the plant apparently died out. Major Trevor Clarke was, in the sixties, experimenting with Indian varieties, but I have been not able to find any record of his results.† In 1903, Professor Gammie,‡ of Poona, published a tentative classification of Indian cottons, and with this some account of crosses that he had made of Indian cottons, *inter se*

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* Watt, Sir George, (1) "The wild and cultivated cotton plants of the world" 1907, p. 333 *et seq.*

† *Ibid*, p. 336.

‡ Gammie, G. A., (2) "Classification of the Indian cottons (tentative)" 1903, p. 15.

and also with the naturalised American "Dharwar" (*G. hirsutum*). His success in crossing the latter species with *Varadi*, with *Kumpta* and with *Nagpur* or *Kil*, varieties which belong to the great group of African-Asiatic species (Watt's section II of the genus *Gossypium*) proves that such hybrids are possible,* but they are difficult to obtain, and appear to be very unfertile, for he says of all that he obtained only one survived.† In his account too of the crosses made between Indian varieties themselves, he says nothing of the second and succeeding hybrid generations. Mr. F. Fletcher, in a Bulletin on Bombay cottons,‡ gave details of some crosses that had been made, but these like those of Prof. Gammie were with reference to the lint alone, and were not on Mendelian lines. The same worker had a note, later on, in the "*Journal of Agricultural Science*"§ on "Mendelian inheritance in cottons," in which he stated that dominance was shown in several characters, among others by the fineness, length and colour of the lint, (which I have also observed in another cross) by the yellow colour of the petals (over white) and by fuzziness of the seed over nakedness. But his figures were for the first and second generations only. That this would hold for later generations and that therefore Mendel's law was applicable was not shown. Mr. Lawrence Balls, who has been working on Egyptian cottons, has also published papers on the subject.‖ ¶ ** He believes that cross-fertilisation by insects occurs to a very considerable extent in the field, and in this he is in agreement

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* Natural hybrids are occasionally found where "Indian" and American varieties are grown together. Sir George Watt considers *jowari* "to have arisen from such a natural cross. Watt, *ibid.*, pp. 338, 339.

† Gammie, G. A. (3) "The Indian Cottons," 1905.

‡ Fletcher, F. (4) Bulletin No. 26 of the Bombay Agricultural Department, 1907.

§ Fletcher, F. (5) "Mendelian Inheritance in Cottons," Journal of Agricultural Science, Vol. II, Dec. 1907, p. 281.

‖ Balls, W. Lawrence. (6) "Note on Mendelian Heredity in Cottons," *ibid.*, p. 216.

¶ (Idem). (7) "Studies of Egyptian Cotton," Year Book of the Khedival Agricultural Society, 1906.

** (Idem). (8) "Mendelian Studies of Egyptian Cotton," Journal of Agricultural Science, Vol. II, p. 347 *et seq.* (July 1908).

with Leake,* myself, and others, in regard to an entirely different set of plants, the Indian cottons. I became acquainted with his work, as also with Fletcher's and Leake's, only after the manuscript of this paper had been written, but I have referred in foot-notes to his and their results where they touch on mine. Mr. Leake published* after this was written, a note on the variation and inheritance of certain characters in cotton plants. He determined by measurement the factor $\frac{\text{length}}{\text{breadth}}$ of the lobes of a leaf, in a number of cases, and found that when a *G. indicum* having rather narrow lobes, was crossed with a *G. arboreum* with broader lobes, the hybrid was of an intermediate type. The next generation, he says, "contained, among others, plants with typical "broad"—and typical "narrow"—"lobed leaves," but he gives no statistics to show the numerical distribution of the different types, nor, as far as I know, has any full statistical account been published of experiments with cottons on Mendelian lines.

The experiments described in this paper, of which a preliminary account was sent to the "Director of Agriculture," Madras, in 1906, were begun in the autumn of 1904, soon after my arrival in India, with a view to determining whether the results of crossing Indian varieties of cotton plants, could be described by any "law," which would guide one in attempting to breed new and improved races, and whether any unit characters exist or can be found which can be passed on undiluted from one variety to another. My observations go to show that such unit characters do exist in both vegetative and floral organs. I have followed the behaviour of three such pairs, the rounded herbaceum or pointed neglectum, shape of leaf, the white or yellow colour of the flower, and the white fuzzy or black naked seed, for five generations, and from observations of some hundreds of plants (817 in the 4th generation, 1177 in the 5th) conclude that the characters studied do really segregate on Mendelian lines. Balls (18) and Fletcher†(4)

* Leake (9) "Studies in the Experimental Breeding of Indian Cottons," Journal of the Asiatic Society of Bengal. New Series, Vol. IV, 1908, No. 1.

† Fletcher, F. (1) Bulletin No. 26 of the Bombay Agricultural Department, 1907.

have anticipated me in the publishing of similar conclusions, with other varieties of Egyptian and Indian cottons, but these are based, as far as the published results show, on two generations only and on a much smaller number of plants.

The practical outcome of these observations appears to be that the cross-breeding of these varieties could be carried on with almost mathematical precision, and if, as seems likely, these principles apply to other characters as well, one might expect to obtain any desired type in a very few years.

As I could obtain no information as to what crosses would succeed, or would be likely to give useful or interesting results, I started with a few different kinds, the seed of which, from the Government farms at Bellary and elsewhere, was kindly given me by Mr. Charles Benson, at that time Deputy Director of Agriculture, Madras. They consisted of a red-flowered tree-cotton named *Karehathi, Jari* and *Bani* of the Central Provinces, *Jowari* (fuzzy and naked seeded) *Northerns Bilaihathi* and *Yerrapathi* of this Presidency. In addition, there were two races of American upland cottons, a naturalised "Kidney" tree-cotton, and another tree-cotton, related apparently to *G. peruvianum*. Hybrids were readily obtained by crossing these exotics *inter se*. From one of the American uplands (W. H. Cooke) and the tree-cotton (*G. peruvianum* were obtained a number of bushy plants very like some I saw grown from seed supplied by Messrs. Shaw, Wallace & Co. of Calcutta, as a new variety. The lint was long and silky and the plants were intermediate in size between the two parents, those from seed of bolls on the tree being slightly larger than those by the reverse cross but otherwise very similar.

As my concern was with the indigenous races, these and the other exotic hybrids were allowed to die out, but in the twenty plants of which I have notes, the red colour of the leaf stalks, and the pink spot at the base of the leaf-blade,*—characters belonging to the herbaceous parent, and the pink spot at the base of the

* Cf. also Balls (8).

petals, and the naked surface of the seed of the tree-cotton were dominant characters. This is so far interesting as the red colour of the leaf-stalks and the nakedness of the seed, were dominant also in totally different crosses between two Indian races.

The seeds were all sown in my garden in September 1904, and the Indian varieties came into flower two months later. The local races—*Northerns Bilaihathi Jowari* and *Yerrapathi*—had been grown for some years on the Government farm at Bellary, and might be considered pure. The ten or twelve plants in each bed appeared to be very similar. But among the *Jari* and the *Bani*, from the Central Provinces, were two plants having large yellow instead of small white flowers. Attempts to cross the two kinds of *Bani*—the yellow and the white flowered—were not successful, but the yellow flowered *Jari* was crossed with other plants. (Table II, No. 4.)

I found it necessary to remove the anthers early in the morning as soon as it was light (and even before daybreak in the case of the "Americans") as they mature and shed their pollen very early. Sir George Watt quotes* Major Trevor Clarke's advice to apply the pollen overnight, "*i.e.*, just before the flower has expanded or has been attacked by pollen-bearing insects." This advice would apply more to the American varieties than to those I was dealing with. I tried removing the anthers overnight, covering the styles, and pollinating them the next day, but gave this plan up, as it was difficult to know which flowers would open the next morning, and none of my crosses so made were successful. I am inclined, however, to think that evening is the best time for removing the anthers, as in the morning they are so nearly ripe, that they are liable to burst and shed the pollen while being removed, and I had to give up a large number of flowers on that account. All who have worked at cross-pollination of flowers, are, I believe, convinced of the extreme sensitiveness of the stigma,—Charles Darwin often insisted on this—and it

* Watt. (1) *Ibid*, p. 338.

was found almost impossible to remove grains from the stigma without injuring its receptiveness.

To emasculate a flower, the bracteoles and petals were first removed before the latter had opened, and the anthers cut off with a pair of fine pointed scissors, beginning from above and working downwards, so as to prevent them touching the stigma. It was then pollinated from some other plant and covered with a small paper bag, about 3 inches long and one inch wide, and a small label was attached to the flower-stalk, with the registered number. If not pollinated immediately it was covered and labelled and crossed later on in the day with pollen from a previously covered flower, and again covered with the paper bag. The number of the cross and of the parents were entered both on the label and in a book. My first pollinations were made in the mornings, but as the pollen did not then adhere well, I often left them till the afternoon.

The weather appears to exert a decided influence on the germination or fertility of the pollen grains. In the following table are given the numbers of cross-pollinations made, and of ripe bolls obtained from them, together with the average percentage of cloud in the sky, as determined at the Madras Observatory for the periods stated :—

TABLE I.

Periods..... days ending.			Number of pollinated styles.	Number of bolls.	%	Average cloud.
5 days to	Nov.	9 ...	17	2	12	40
Do.	do.	14 ...	34	5	14·7	53
Do.	do.	22 ...	—	—	—	30
——	do.	23 & 24 ...	35	12	34	09
5 days to	do.	29 ...	77	21	27·2	29
Do.	Dec.	4 ...	20	3	15	72
Do.	do.	9	6	1	16·6	49
Do.	do.	14 ...	22	6	27·3	37
Do.	do.	*19 ...	15	1	6·5	53*
Do.	do.	24 ...	—	—	—	—
Do.	do.	29 ...	8	1	12·5	40

That fine bright days are the best for setting of flowers, is, I believe, the experience of gardeners, and these figures amply

* Rain fell on the 18th to 21st.

bear this out. The highest % (34) of successful pollinations being when the average cloud was least (·09) and *pari passu* the more cloud the fewer fertilised bolls. Mr. Charles Benson told me that rain or even heavy dew would often cause half ripened bolls to drop, and a good many were lost, probably from this cause.

I collected the hybrid seeds myself, and after picking off the floss sowed them in pots from which the young plants were put out into beds, in February 1905. The uniformity of the crosses between *Jari* and the local "*herbaceums*" was very striking. They were all alike in having the red stems and petioles and narrow-lobed leaves of *Jari*, but had the full yellow flowers of *Jowari*, *Northerns* and *Bilai*. One lot, No. 3 in tables II and V and i. in table X came into boll in April, and by sowing seed at once, I obtained a second generation crop before the November rains. This was sown along with seed from the others on land hired near Madras, when I had, therefore, one lot a generation ahead of the others.

The plants of the first generation, with the exception of the lot just referred to (fig. 15) were all larger and more vigorous than their parents. This increased vigour was continued in the 2nd, 3rd and 4th generations, and was very marked. Those of each bed—*i.e.*, from each hybridised boll—were, as far as I could see, very much alike. In the 2nd generation, however, the utmost diversity appeared among the descendants of the *Jari* and "*herbaceum*" and *Bani* and "*herbaceum*" crosses. Some grew tall and straight, branching stiffly at right angles (fig. 16), others were low with spreading branches (fig. 17). Some had broad lobed leaves of the "*herbaceum*" or "*obtusifolium*" type, others had the long narrow pointed lobes of *Jari*. While, moreover, all in the first generation had yellow flowers, a considerable number of the 2nd generation from a white and yellow flower cross had pure white flowers. Some had short rounded bolls like those of the original *Jowari*, in others the bolls were long and pointed. Again, the short coarse nature of the lint (floss) of the *Jari* and *Bani* parents was absent in the first generation, but appeared in the second. And Mr. C. Benson drew my attention

to the similarity exhibited by some plants in one lot—from a cross between Bani and *Jowari*—to "American uplands," the broad flat leaves and spreading branches reminding one of that type.

The cotton plant appears to attract a large number of insects. Large red striped beetles bit through at the base of the flowers and destroyed the style. The latter too was often damaged in the bud by caterpillars. Boll-worms destroyed the seed, but the greatest damage was, I think, done by the "scarlet cotton-bug," and the small "dusky cotton-bug," which attacked the seed as soon as a boll opened, and were never got under, though a small boy was employed to go round and shake them off into a tin of paraffin. Any seeds that were left on the bushes were quickly eaten by ground vermin. They had, therefore, to be collected almost daily, and the picking from so many separate plants was very tedious. There was the further disadvantage that the field being some way out of the town, work there was necessarily intermittent, and the flowers and seeds of some plants were on that account never seen. The next year I was given by the authorities the use of land on a Government experimental farm, where my plants were well looked after by the manager, who also, while I was unavoidably absent from the country, made many of the notes on which I base the figures of the fourth generation.

But most of the seeds sown there failed to germinate. Cotton seed is known to keep badly during the hot weather if ginned, as mine were. Or it may be that in the damp atmosphere of Madras these seeds were never properly dried, and so were particularly susceptible to heat. The local Horticultural Society has always found that imported garden seed, especially those of an oily nature, rapidly deteriorate in germinating power. In my case over 8,000 seeds from selected plants of F. 2 were sown, but those that did come up were all washed out of the light sandy soil by a heavy fall of rain which occurred soon afterwards. The whole of these on which I was relying for my third generation were therefore wiped out, and I have to fall back on the 240 plants from F. 1, No. 3, referred to above as grown the previous season near Madras. This was the more unfortunate, as the characters

of the parent plants had been very carefully noted, and as these were still growing it was hoped to compare the new generation with them, while less attention had been paid to these other few plants.

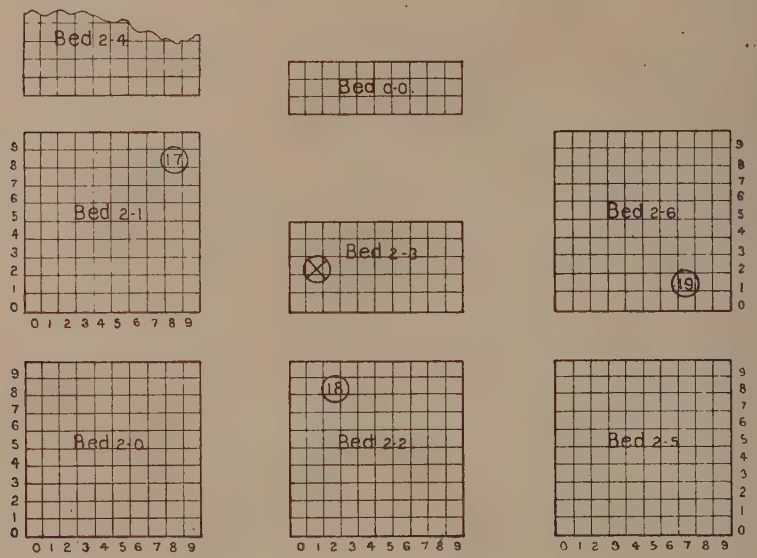
I had not made a point of collecting seed from the other lot, but sufficient had been taken from a few of the plants, for the fourth hybrid generation, and on another part of the farm enough were grown to indicate the distribution of the characters (tables IV, IX and XII).

ON THE ARRANGEMENT OF THE PLANTS.

The original plants and the first hybrid generation were set out in numbered beds and named by letters of the Greek alphabet. But as the number of plants which could be so named in any bed was thus limited, by the number of letters available, and the naming was somewhat cumbersome, I adopted for the second and subsequent generations another system, which I will shortly describe, as it is so well suited for work of this kind, and I have not seen anything similar referred to in accounts of breeding experiments.

The plants were arranged in rows, about two feet apart or more. In each row were 10 plants, and 10 rows constituted a rectangular bed. The rows were numbered 0 to 9, and the plants in each row, from left to right, also 0 to 9. No labels were affixed, except here and there, if experience showed on account of overcrowding or irregular growth, a plant might be wrongly numbered. Each plant in fact has a number depending only on its position in the bed, thus the 4th plant of the 6th row would be No. 53 of that bed. The first plant of the bed is 00. The last 99. The beds of any one lot were also numbered, and by using also the registered number of the whole lot of seeds, the position and origin of any plant was defined and could be easily and shortly written down. Thus fig. 16 is from the photograph of a plant No. 2321, *i.e.*, the second plant of the 3rd row in the 4th bed of lot 2, the position of which is shown in the plan (X). Fig. 17 is of No. 2188, the 9th plant of the 9th row of the 2nd bed of

the same lot. These are from photographs taken in the field. Fig. 18 is of a dried piece from No. 2282, fig. 19 of No. 2617.



Copy of part of the plan of the field to show method of numbering the plants for their identification by their position.

BED 2—0.

9	Y	P	Y	W	Y	Y	W	Y	W	Y
8	Y	P	Y	P	Y	W	W	P	W	P
7		W	Y	Y	Y	Y	W	Y	Y	Y
6	W	W	Y	Y	Y	Y	W	W	Y	Y
5	W	P	Y	P	W	P	P	W	Y	Y
4	W	P	W	W	W	Y	P	W	W	Y
3	W	P	Y	Y	Y	W	P	Y	W	P
2	Y	Y	W	W	P	Y	Y	Y	W	W
1	Y	Y		W	W	W	Y	W	P	Y
0	Y	W	Y	Y	Y	Y	Y	W	Y	W
	0	1	2	3	4	5	6	7	8	

Yellow flowers ...	... 47
Pale ,, ...	... 17
White ,, ...	... 34
Plants died ...	... 2

The taking of notes of the plants was also very much simplified by this system. A square ruled to 100 small squares represented a bed, each small square representing a plant. It is only necessary to write in the square some letter or symbol denoting the nature of the character noted. Thus the colours of the flowers in the bed marked 2-0 in the plan were noted as in the accompanying note-book plan of the bed.

THE LEAF.

Crosses were made between all the Indian races named above, but the two species which differed most in the shape of the leaf were *Jari* (*G. arboreum* Linn. var. *neglectum* of Watt ; *G. neglectum* Tod. of Gammie) and *G. obtusifolium* Roxb. (of Watt) or *G. herbaceum* Linn. (of Gammie) represented in my beds by *Northerns*, by fuzzy seeded (white) *Jowari*, by naked seeded (black) *Jowari* and by *Bilaihathi*. Figures 1, 2, 3, 4, show the characteristic shape of their leaves.

The following table gives the number of bolls and of plants obtained.

TABLE II.

Fig.	Seed plant.	Pollen plant.	Bolls.	Plants.	Leaves like.
1	Jowari fuzzy ...	Jari white flower ...	2	19	.....
2	Jari white flower ...	Jowari fuzzy ...	1	11	Fig. 5
3	Jowari naked ...	Jari white flower ...	1	16	,, 6 & 7
4	Bilaihathi ...	,, yellow flower ...	2	16	,, 17
5	Northerns ...	,, white flower ...	4	58	,, 8
6	Jari white flower ...	Northerns	1	11	,, 9
		Total ...	11	131	

All these 131 plants were without exception like *Jari* in the shape of the leaf.* Figures 5 to 9 were drawn to scale from

* It might appear that my observations are here at variance with those of Leake who (9 p. 15) says the hybrids he obtained were intermediate between the parents. But his crosses were between *G. arboreum* and *G. indicum*, while mine were between *G. neglectum* and *G. herbaceum*, species which are probably less closely connected. The cases are, therefore, not analogous, nor the observations necessarily contradictory.

representative leaves. The uniformity of the plants of a bed was most striking: this was particularly the case with lot No. 3, which were all small plants and sparingly branched like their *Jari* parent, with large bright yellow flowers like *Jowari* (fig. 15).

Seed was collected from these beds during the months April to August, and from lot No. 3, which were the earliest, some were sown in April. It is from this lot that the plants of the 3rd and 4th generations of this cross were raised. The others were sown in September in small seed-beds and planted out in rows and beds as explained above.

It was at once seen that the *herbaceum* (of Gammie) type of leaf, of which there was no sign in the first generation, (fig. 15) had reappeared in its original form in a large number of plants of the next.

Of those of No. 3, out of 620 plants 370 had leaves like *Jari*, 128 like *Jowari*, 121 more or less intermediate. That is to say 21% had the character which was not present in the first hybrid generation.

From No. 4, of 102 plants 54 were like *Jari* and 22 like the *herbaceum*, a percentage of 21·6. Of lot No. 5 however a larger proportion were classed as intermediate—of 163 plants 114 were like *Jari*, 33 intermediate, and 16 *herbaceums*. I refer only to the general form of the leaf. *Jari* and *Jowari* leaves differ also in texture and surface, but it was difficult in the short time available to discriminate these characters. Some classed above as like *Jari* had for instance even narrower lobes, and had the soft feel and surface of *Jowari*. In a few the margins of the leaves were waved, a strikingly exaggerated instance of this being shown in fig. 10.

Table III shows the behaviour of the plants from *neglectum* (*Jari*-like), and of the *herbaceum* or *Jowari*-like plants in the next generation.

TABLE III.

The third hybrid generation.

No.	PARENTS' LEAF.	Negl.	Herb.	TOTAL. N	H.
1	neglectum	7	..	.	...
2	do.	10	...	..	.
3	do.	6	..	..	...
4	do.	6	...	...	...
5	do.	20	...	49	0
6	do.	17	5	...	
7	do.	6	3	...	..
8	do.	12	5	..	..
9	do.	23	5	58	18
10	do.	?	?	.	..
11	do.	?	?	...	...
12	do.	?	?	..	..
13	herbaceum	...	30	..	...
14	do.	...	26	...	...
15	do.	1	20	...	...
16	do.	...	8	1	84

Nos. 1 to 5 appear to have been, as regards the shape of the leaf, pure *neglectums*; my impression is that the progeny of Nos. 10—12 were also all *neglectums*, but as it was not intended to deduce the distribution of characters from this lot,* no notes were made of their leaves. They are introduced here as notes were made of their flowers and seed.

The other '*neglectum*-leafed' parents (Nos. 6 to 9) gave out of 76 plants, noted, 18 *herbaceums*, which is almost exactly the Mendelian expectation ($\frac{1}{4}$ of $76 = 19$). Nos. 13 to 16 bred practically true to the *herbaceum* character, there being only one stray *neglectum* among 85 plants.

* See page 8.

TABLE IV.

The fourth hybrid generation.

No.	PARENT.	Negl.	Herb.	Negl.	Herb.
1	neglectum	13	...	...	...
2	do.	188	...	...	...
3	do.	6	...	157	0
4	do.	37	3	...	...
5	do.	67	7	...	...
6	do.	15	5	...	...
7	do.	7	6	...	...
8	do.	36	10	...	...
9	do.	94	16	...	...
10	do.	60	67	...	...
11	do.	12	7	328	121
12	do.	1	9*	...	...
13	do.	4	2	...	...
14	do.	8	19	...	...
15	intermediate or herbaceum ...	5	40	...	...
16	do. do. ...	4	20	...	...
17	do. do. ...	3	20	...	...
18	do. do. ...	1	53	...	...
19	do. do. ..	3	62	16	195

In the fourth generation a similar distribution holds. Three of the *neglectums* were pure dominants. Nos. 4 to 11 gave out of 449 plants, 121 recessives. Theoretically the number of these should be 112. The last five were probably pure *herbaceums*. But they stood amongst *neglectums*, to crossing with which the 8% of *neglectums* are probably due.

TABLE V.

The fifth hybrid generation.

No.	No. in table IV.	LEAVES OF		Negl.	Herb.	TOTALS.	
		Grandparent.	Parent.			N.	H.
1	2	neglectum ...	neglectum ...	218	1	...	...
2	6	do. ...	do. ...	38	0	...	...
3	8	do. ...	do. ...	73	0	...	...
4	9	do. ...	do. ...	86	0	...	...
5	12	do. ...	do. ...	20	0	...	...
6	13	do. ...	do. ...	46	0	481	1
7	6	do. ...	do. ...	15	5	...	...
8	8	do. ...	do. ...	15	6	...	...
9	9	do. ...	do. ...	38	5	...	...
10	12	do. ...	do. ...	7	3	...	...
11	16	intermediate ...	do. ...	6	11	91	30
12	8	neglectum ...	herbaceum ...	1	10	...	...
13	16	intermediate ...	do. ...	6	135	...	...
14	18	do. ...	do. ...	1	334	...	...
15	19	do. ...	do. ...	1	181	8	639

* These numbers are not included in the totals, as they represent only a few plants out of a much larger number of seeds sown, and no importance can therefore be properly attached to them. But some of the plants are the parents of some in the next table.

The second column of figures refers to the number of the parent in table IV.

The parents in lots 1 to 6 appear to have been pure *neglectums*, for with the exception of one stray plant in line 1, all the offspring were *neglectums*. Those of lots 6 to 11 were hybrids and the proportion of *herbaceums*—30 out of 121—is exactly the expected Mendelian ratio of one-fourth. There are a few *neglectums* among the offspring of *herbaceum* parents (lots 12 to 15), but four of them were in one bed, and the rest may perhaps safely be taken as accidental inclusions. We see therefore that among plants of the fourth generation, as of the two preceding, there were two kinds of *neglectums*—pure and hybrid, the offspring of the latter showing the dominant and recessive characters in the proportion of 3 to 1.

THE FLOWER.

Most of the Indian varieties of cotton plants have yellow flowers, marked in the centre with red or purple, which in the evening fade to a terra-cotta colour. But two of the varieties with which I began these had comparatively small white flowers, marked also with purple, but fading to a pink colour. These were the white flowered *Jari* and *Bani*. Thirteen successfully crossed bolls were obtained between white and yellow flowered indigenous races thus :—

TABLE VI.

	Seed Plant.	Pollen Plant.	Bolls.	Yellow.	White.
1	Jowari	Jari	2	19	...
2	Jari	Jowari	1	11	...
3	Jowari	Jari	1	16	...
4	Northerns ...	Do.	4	58	...
5	Jari	Northerns ...	1	11	...
6	Jowari	Bani	3	24	...
7	Bani	Jowari	1	16	...
8	.....	.....	...	...	...
		Total ...	13	155	0

The flowers all appeared when fresh to be of a full yellow colour and not intermediate in tint or size between those of the

parents, and whether the yellow colour was supplied by pollen or by the ovule made no difference.

In the next generation, however, there were many plants with perfectly white flowers exactly like their *Jari* or *Bani* grandparents, and also some of a pale colour. In some cases these were observed to fade to a terra-cotta colour like the yellow flowers, in others to turn pink like the white flowers. The yellow and pale flowers were large and open like the "*herbaceums*," and a few of the white were also large. But nearly all the white flowers were small and like those of *Jari* in shape, and there were no small yellow flowers observed.

The following is the distribution of flowers in the next generation :—

TABLE VII.

Second hybrid generation.

No.	F.	Yellow.	Pale.	White.	% White.
1	3	287	110	178	31
2	5	25	5	27	...
3	6	182	15	85	30·2
4	6	83	10	57	...
5	6	76	8	32	...
6	6	35	0	11	...
7	6	41	8	21	...
	Total ...	729	156	411	31·6

In some beds notes were not made of the flowers of all the plants, for some did not appear to flower at all, others only seldom, and continuous work not being possible, these latter were sometimes missed.

TABLE VIII.

The third hybrid generation.

No.	Number in table III.	Parent.	Yellow.	Pale.	White.	TOTALS. Y.	P.	W.
1	10	Yellow ...	21	...	...	21	0	0
2	8	Do. ...	25	...	11			
3	12	Do. ...	25	1	2			
4	5	Do. ...	13	...	3			
5	11	Do. ...	10	...	6			
6	7	Do. ...	7	...	2	80	1	24
7	13	Do. ...	*12*	...	*1**			
8	14	Do. ...	*6*	...	*7**			
9	3	Do. ...	*2*	...	*1**			
10	9	Pale ...	18	7	9	18	7	9
11	1	White ...	1	...	6			
12	6	Do. ...	...	...	22			
13	2	Do. ...	1	...	8			
14	15	Do. ...	...	...	9			
15	4	Do. ...	..	...	6	2	0	51
16	15	Do. ...	...	*1*	*10*			

The first plant (Table III, No. 10) was evidently a pure yellow. Nos. 2 to 6 gave 23% whites, 76% yellows. Of Nos. 7, 8 and 9 of this table, not enough plants were observed in flower to give full numbers, but they were evidently hybrid yellows.

The white-flowered plants gave nearly all whites. No. 15 (Table III, No. 4) was, as regards leaf and flower, a pure *Jari*.

TABLE IX.

The fourth hybrid generation.

No.	Grandparent.	Parent.	Yellow.	Pale.	White.	TOTALS. Y.	P.	W.
1	Yellow ...	Yellow ...	20	..	...	20	0	0
2	Do. ...	Do. ...	76	6	4			
3	Do. ...	Do. ...	11	...	4			
4	Do. ...	Do. ...	47	..	13			
5	Do. ...	Do. ...	26	...	10			
6	Do. ...	Do. ...	50	...	21			
7	Do. ...	Do. ...	5	13	1			
8	Do. ...	Do. ...	37	3	12			
9	Do. ...	Do. ...	72	...	45			
10	Pale ...	Do. ...	33	...	11			
11	Do. ...	Do. ...	82	13	37			
12	Do. ...	Do. ...	30	6	10	469	41	166
13	Do. ...	Pale ...	10	2	1			
14	Do. ..	Do. ...	3	1	2			
15	Do. ...	Do. ...	2	...	10			
16	Do. ...	Do. ...	14	2	8	29	5	21
17	Yellow ...	White ...	*5*	*0*	*2*			
18	Do. ...	Do. ...	*5*	*1*	*2*			
19	Do. ..	Do. ...	...	...	27	0	0	27

* These were all that were observed in flower, of a much larger number of actual plants growing; they are therefore not included in the total. It is fair to point out, that if they were

No. 1 appears to have been a pure yellow, and No. 19 a pure white-flowered plant. Nos. 2 to 12 gave between them, out of a total of 676, 166 whites or 24·2% of recessives. On the Mendelian theory, the number should have been 169—a very close approximation.

TABLE X.

The fifth hybrid generation.

No.	No. in table IV.	Grandparent.	Parent.	Yellow.	White.	Totals.	
						Y.	W.
1	2	Yellow ...	Yellow ...	13	..	...	..
2	8	Do. ...	Do. ...	13	..	..	...
3	9	Do. ...	Do. ...	9	...	...	...
4	15	Do. ...	Do. ...	28	...	...	...
5	18	Do. ...	Do. ...	53	...	116	0
6	2	Do. ..	Do. ...	129	54	...	..
7	8	Do. ...	Do. ...	108	44	...	...
8	9	Do. ...	Do. ...	26	6	...	...
9	15	Do. ...	Do. ...	177	58	...	...
10	16	Do. ...	Do. ...	83	27	...	...
11	18	Do. ...	Do. ...	90	26	613	215
12	2	Do. ...	White ...	1	81	...	...
13	6	Do. ...	Do. ...	...	6	..	...
14	8	Do. ..	Do. ...	...	6	...	...
15	9	Do. ...	Do. ...	...	5	...	...
16	18	Do. ...	Do. ...	1	2	...	...
17	19	Do. ...	Do. ...	1	86	3	193
18	13	White ...	Do. ...	3	41	..	...
19	..	Do. ...	Do. ...	1	31	4	72

The difference between yellow and white flowered plants is again plainly shown. The first five plants were pure yellows, and gave not a single white in over a hundred plants. The next six were hybrid yellows, and from them out of 828 plants 215 or 26 % were whites, a very close approximation to the expected ratio of 25 %. Extracted whites gave of nearly 200 plants, only 1·5 % yellows. The last two plants were in small beds among yellows to vicinism with which the yellows among them are probably due.

THE SEED.

Cotton seeds differ in shape, in size, and in colour—*i.e.*, after removal of the "floss" or "lint" the surface may be

included, the proportion of white to yellow or pale—33 to 101—would be almost exactly the expected Mendelian ratio of 1 to 3.

glabrous and black, or be covered by a more or less dense coating of short hairs, the "velvet" or "fuzz." Size is not a character easily discriminated, as it may depend on several factors. There is more real difference in the shape, the seeds of *Jowari* being for instance round, with a hard prominent beak. But attacks of seed-sucking insects, particularly of the Scarlet Bug (*Dysdercus cingulatus*), and the Dusky cotton-bug (*Oxycarenus laetus*) so altered the shape, that attempts to discriminate between the seeds in this respect were given up. One variety—*Tellapatti* or black seeded *Jowari* differs from all the other Indian kinds, by having a smooth glabrous seed coat of a dark brown or black colour. Sir George Watt in his book (1) p. 152, says of this "There would seem little doubt that this is a naturally produced hybrid between the *uppam* and Bourbon cottons" and "the same seed on germination may produce" some or more fuzz. The possibility of its being such a hybrid had not occurred to me, for I looked upon it as a variety merely of the white or fuzzy *Jowari*. Nor, as far as I can see, does Prof. Gammie in his classification of Indian cottons (1903-1904 and 1905) give a hint of such an origin. Crosses were made of this race with the normal fuzzy *Jowari*, and with *Jari*.

Table XI shows the numbers of bolls and of plants obtained from them.

TABLE XI.

Bolls.	Seed Parent.	Pollen Parent.	Naked.	Inter.	Velvet.
a	Jowari fuzzy ...	Jowari naked ...	5	0	0
b	Do. do. ...	do. do. ...	16	0	0
c	Do. do. ...	do. do. ...	0	11	0
d	Do. do. ...	do. do. ...	0	0	10
e	Do. naked ...	do. fuzzy ...	6	0	1
f	Do. do. ...	do. do. ...	12	0	0
g	Do. do. ...	do. do. ...	0	12	0
h	Do. do. ...	do. do. ...	16	0	0
i=3	Do. do. ...	Jari	16	0	0
		Total ...	71	23	11

With the exception of boll "d," and of one plant out of boll "e," no fuzzy-seeded plants were obtained in the first generation by crossing the two kinds. These exceptions must, I think,

be taken as due to self-pollination, and to be not hybrids at all. The seeds of the plants from "c" were very nearly naked, and of those from "g," I have a note that though not quite clean, they were very like those of *Tellapatti*. Leaving "c" out of account therefore 8 bolls gave between them 95 plants,—71 having perfectly naked seeds, 23 nearly naked, and 1 fuzzy seed. As "i" which was the same as Table II No. 3, in previous table, was the most interesting cross on the whole, and also the most prolific in seed, attention was mainly directed to its progeny.

In the next generation, F. 2, many of the plants again had perfectly clean black seeds, but in others it was covered with a fuzz, as dense or even denser than that of the original *Jari* parent. Most of the plants could easily be classified as having naked or "fuzzy" seeds, but there were differences in the thickness of the covering, and in some the black seed-coat could be seen through it.

A considerable number were nearly naked, having varying quantities of short fuzzy hairs – either as a tuft at one or both ends, or extending half over the surface of the seed.

I divided them therefore into four groups. Those of No. 3 (Boll i) were as follows :—

Naked	207
Nearly naked	69
Thinly fuzzy	13
Fuzzy	304

There were fewer intermediates in the plants of the third generation, the distribution being as in Table XII.

TABLE XII.

The third hybrid generation.

No.	No. in Table III.	Parent.	Naked.	Inter.	Fuzzy.	TOTALS.		
						N.	I.	F.
1	16	Naked ...	8	...	...	8	0	0
2	2	Do. ...	9	1	...			
3	6	Do. ...	16	3	...			
4	8	Do. ...	19	6	10			
5	12	Do. ...	16	6	7			
6	1	Do. ...	4	...	3	64	16	20
7	5	Do. ...	*6*	...	*11**			
8	4	Do. ...	*3*	...	...			
9	7	Intermediate ...	2	1	5	2	1	5
10	9	Fuzzy ...	...	3	31			
11	11	Do. ...	...	1	16			
12	10	Do. ...	...	1	20			
13	4	Do. ...	...	...	6			
14	5	Do. ...	...	...	16	0	5	89
15	14	Do. ...	...	...	*8*			

The first on the list was a pure clean or naked-seeded plant. Of the next five, 20% were quite fuzzy, 64% quite naked.

From the really fuzzy seed, no naked-seeded plants were got, but there were about 5% of plants whose seed had a thin fuzz with black seed coat underneath.

TABLE XIII.

The fourth hybrid generation.

No.	Grandparent.	Parent.	Naked.	Inter.	Fuzzy.	TOTALS.		
						N.	I.	F.
1	Naked ...	Naked ...	7	...	4			
2	Do. ...	Do. ...	14	2	2	21	2	6
3	Intermediate ...	Do. ...	*20*	*3*	*20*			
4	Do. ...	Do. ...	*2*	*1*	*6*			
5	Do. ...	Do. ...	1	...	4			
6	Do. ...	Intermediate ...	*3*	...	*11*			
7	Do. ...	Do. ...	31	7	36			
8	Do. ...	Do. ...	10	5	21	41	12	57
9	Naked ...	Fuzzy ...	...	...	29			
10	Do. ...	Do. ...	...	1	55			
11	Do. ...	Do. ...	...	...	7			
12	Do. ...	Do. ...	...	...	8			
13	Do. ...	Do. ...	...	...	45			
14	Do. ...	Do. ...	2	3	105			
15	Do. ...	Do. ...	2	...	22	2	4	249
16	Fuzzy ...	Do. ...	...	1	65			
17	Do. ...	Do. ...	1	...	38			
18	Do. ...	Do. ...	...	...	6			
19	Do. ...	Do. ...	...	...	12	1	1	121

* Figures in italics mean that these were all that were observed of a much larger number.

Of Nos. 1 and 2, rather less than one quarter were fuzzy-seeded. The small proportion of naked and intermediates among those of fuzzy-seeded parents, whether extracted from naked grandparents or not, is very striking and in marked contrast to others. Intermediates appear to give about half naked and half fuzzy.

Table XIV.

The fifth hybrid generation.

No.	No. in table IV.	Grand parent.	Parent.	Naked.	Fuzzy.	Totals.	
						N.	V.
1	8	Naked ...	Naked ...	4	...		
2	9	Do. ...	Do. ...	6	...	10	0
3	2	Do. ...	Do. ...	7	4		
4	8	Do. ...	Do. ...	6	2	13	6
5	8	Do. ...	Fuzzy ...	8	25	8	25
6	8	Do. ...	Do. ...	1	135	1	135
7	2	Fuzzy ...	Do. ...	...	129		
8	2	Do. ...	Do. ...	6	122		
9	9	Do. ...	Do. ...	...	5		
10	13	Do. ...	Do. ...	...	68		
11	15	Do. ...	Do. ...	2	259		
12	16	Do. ...	Do. ...	8	97		
13	16	Do. ...	Do. ...	...	24		
14	18	Do. ...	Do. ...	1	138		
15	19	Do. ...	Do. ...	...	87	17	929

The first two were probably pure naked-seeded plants, the next two hybrids. There was apparently a certain amount of intercrossing with naked-seeded plants growing near by, but on the whole the velvet seeds came very fairly pure to their kind. Except in the case of Nos. 5, 8 and 12, there were either no naked-seeded plants at all or less than 1%.

SUMMARY AND CONCLUSIONS.

The first and most obvious result of crossing was a great increase in the size and vigour of the plants. This is in accordance with general experience. In the cross *Jowari* × *Jari* the results of which form the substance of this paper, the first hybrid generation, the immediate results of the crossing were indeed small plants (fig. 11), but the next and succeeding generations contained some which were large bushes running up to six or

seven feet in height.* In other cases this increase in vigour was evident from the first. On the whole, too, the plants bolled freely and bore well, though some of the third generation of lot No. 3 were very poor. The smaller and *neglectum*-leaved plants came into bearing first, and two were especially marked in this respect, bearing heavily while the majority were still only in flower. As their seeds were naked and had long and silky staple, it was hoped that they might prove the progenitors of a useful variety, but as explained above (p. 8) none of the seeds of that lot survived.

Secondly, the plants were in some cases very variable, as is often observed with hybrids, Charles Darwin calling attention† to this in "animals and plants." According to the pure Mendelian theory, while the individual unit characters may change places, and combine in every way that chance may direct, so that the plants as a whole appear variable, each unit character should appear in itself true. In the shape of the leaf I found considerable variation, the lobes of some *neglectums* being very narrow, almost linear, and a few had wavy margins not unlike those of Assam cotton figured by Watt.‡ These might be due to different combinations § of *Allelomorphs*, but since wavy margins do not occur in the normal leaves of either *Jari* or *Jowari*, and appeared less frequently in later generations, I am inclined to consider them as monstrosities due to variation induced by hybridisation and by change of climate and soil. There is a general tendency too, for plants to approximate in character with age : in those more than twelve months old it is very difficult often to specify the nature of the leaf, or of the branching, and to this must be put down the failure to determine the characters of the lots Nos. 10, 11 and 12 of Table III. See fig. 7 and compare with figs. 11 and 12.

* My original *Jari* plants were small. Balls (8) notes a similar "intensification" of characters.

† Darwin, C. Variation in Animals and Plants under Domestication, 1868, ed. Vol. II, pp. 264, 266, 267.

‡ Watt *ibid.* (1) plate 18. Opp. p. 108.

§ Bateson and Saunders, (11) Report to the Evolution Committee of the Royal Society, p. 144.

THE INTERPRETATION OF THE RESULTS.

It is generally considered that flowers of cotton plants are habitually self-fertilised. Sir George Watt quotes the Danish colonist Rohr* as observing in 1790 that "Fecundation ordinarily takes place in *Gossypium*" before the flower has fully expanded: the same writer later on speaks hopefully of hybridising experiments with cotton,—"a plant that through the early maturity of its stamens (as in Mendel's classic experiments with *Pisum sativum*) is fully under control." † Mr. Charles Benson told me as the result of his long experience of cotton in Southern India, that it is practically always self-fertilised. Other officers of the Agricultural Department have said the same, pointing out that the ryots usually sow mixed seed, and that the absence of intermediate forms shows that crossing does not occur.

Professor Gammie, in his classification of Indian cottons, 1903 and 1905, emphasised the same point. For these reasons it was not thought necessary to cover the flowers, to make sure of obtaining self-fertilised seed for the second and subsequent generations. It would, moreover, have entailed more time and labour than I could give. A few flowers in the first hybrid generation were covered, but the plants so obtained (Bed. 0-0) did not show any less variation than those from uncovered flowers. Yet I think that a certain amount of crossing‡ did occur with my plants, the result of which was most apparent in the offspring of the first hybrid families, the latter being each of a few plants only and in beds close together. The presence of the few yellow flowers in a bed which one would expect to be all white and of *neglectum* leaves among *herbaceums* may, I think, have been due to accidental inter-crossing by the insects which visited the flowers in large numbers. Such inter-crossing almost certainly does occur even if only rarely, among cottons in the field. Mr. Sampson, the Deputy Director of Agriculture, pointed out to

* Watt, (1)., p. 338.

† *Ibid*, p. 341.

‡ Compare also Shull (13) "On Mendelian inheritance of sunflowers." *Botanical Gazette*, Vol. XLV, No. 2, Feb. 1908, p. 106.

me several plants among Karanganis (*G. obtusifolium* Roxb. of Gammie) which showed characters belonging to Uppam (*G. herbaceum* Linn. of Gammie) and Karangani-like plants among Uppams, and there was one which seemed to be a natural cross between "American" type. If these were not natural crosses they were very remarkable instances of variation.*

THEORETICAL.

Though in some cases a considerable proportion of the seeds sown did not produce plants, one may reasonably suppose those that did, to be a fair sample of the lot. There is no *a priori* reason why seeds carrying a "*herbaceum*" leaf character should germinate better than those of the other kind, or that they should have done so, for instance in lots Nos. 13 to 16 of table 3 and not in lots Nos. 1 to 5; and when out of 676 plants (table IX) 166 or nearly 25 per cent. are of one type, this may fairly be considered to have been the proportion of all the seeds sown. Unless this is conceded no conclusion can be drawn from observations of a statistical kind, for one cannot well sow *all* the seeds of a plant, and of every batch of seeds some always fail.

Of the characters observed, two pairs, the *herbaceum* or *neglectum* shape of the leaf, and the white or yellow colour of the flowers, appear to segregate on Mendelian lines. Yellow is dominant over white, a fact which bears out C. Darwin's observation that characters common to a number of species are usually prepotent over those belonging to a few only, for nearly all species of *Gossypium* have yellow flowers.† In this connection it is also interesting to note that in crosses between coloured and white varieties of other genera, it has been found that white is in some cases dominant; in others recessive; and that this appears to depend on the way in which the colour is contained in the cells, Bateson in fact distinguishes two kinds of yellow

* Since the above was written Leake (9) has expressed the opinion that crossing by insects is quite common.

† Balls (8) p. 363 and Fletcher (5) also find red dominant over yellow; and cf. with reference to Alex. Burns and Watt's view of the antiquity of *G. arboreum* (1) p. 86.

coloration.* In Stocks (*Mathiola*) yellow is recessive, as Correns also found in crosses between a white *Polemonium cæruleum* and *P. Flavum*, and in these the colour is contained in plastids.†

In *Verbascum blattaria* L., Shull‡ finds yellow dominant, and here the colour is dissolved in the cell sap. Microscopic examination shows that with cottons in which, too, yellow is dominant it is a sap colour.

The *neglectum* (*arboreum*) shape of leaf is dominant over the *herbaceum*, and if we suppose that here again it is the phylogenetically older character which is dominant, this fact would confirm Sir George Watt's view that "*G. arboreum* Linn. if not an original wild stock, and therefore botanically a species, is remarkably near to what we are justified in believing, may have been one of the ancestral stocks of many of the cultivated cotton plants of the Old World§ and that by cultivation was produced from the original *G. arboreum*, the annual plant now known as *G. herbaceum*."‖

The seed-coat does not appear to behave in exactly the same way : looking at a collection of seeds, from each plant of a bed, one would say at once that the "fuzzy" and "naked" characters obviously segregate. But closer observation shows that there are intermediate grades of "fuzzyness." It may be that these characters really do segregate in the same way as other varietal differences, but are influenced by external conditions, for Fletcher¶ found that in cottons of other species irrigation tends to make the seeds naked.** Or it may be that these characters are "*poikilodynamic*," and while separating in the germ cells, as

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* Bateson (W.). Saunders (Miss E. R.) and Punnett (R. C.) Reports to the Evolution Committee of the Royal Society II and III, 1905 and 1906.

† Correns (C.). Weitere Beitrage zur Kenntniss der dominerenden Merkmaale und der Mosaik-bildung der "Bastarde" Ber. Dentsch. Bot. Gesells. 21 : s. 195—201. 1903, quoted by Shull (13).

‡ Shull (13), p. 115.

§ Watt (1), p. 86.

‖ Watt *ibid*, p. 323.

¶ Fletcher Review of Sir George Watt's Book (1) Nature, Jan. 1908 : Vol. 77, p. 242.

** Among Egyptian cottons Balls finds, on the other hand, much fuzz dominant over little fuzz, and Fletcher (5) in another pair of Indian varieties that fuzz is dominant Neither worker gives details of more than two generations.

unit characters do, are of varying power, so that when combined in the hybrid, the dominance of the one (naked) is not always complete. This sort of thing occurs for instance (according to Shull) (13) in the branching of the sunflower.

Other characters also appeared to segregate, but their behaviour could not be followed after the second hybrid generation, on account of the failure of the third. But as far as the two generations showed, length and fineness of lint were dominant over the short and rough woolly nature, and the habit of the bolls opening widely as in fig. 16 and allowing the seeds to hang down freely (and so be collected cleanly) dominant over that of opening only a little.

If this be so, these important characters like the others of which this has been shown, could be bred into our Indian races of cotton plants without much difficulty.

LITERATURE QUOTED.

(1). WATT, SIR GEORGE ... "The Wild and Cultivated Cotton Plants of the World." 1907.

(2). GAMMIE, G. A. ... Classification of the Indian Cottons (tentative). 1903.

(3). GAMMIE, G. A. ... "The Indian Cottons." 1905.

(4). FLETCHER, F. ... Bulletin No. 26 of the Bombay Agricultural Department. 1907.

(5). FLETCHER, F. ... "Mendelian Inheritance in Cottons." *Journal of Agricultural Science*, Vol. II, Dec. 1907, p. 281.

(6). BALLS, W. LAWRENCE ... "Notes on Mendelian Heredity in Cottons". *Ibid*, p. 216.

(7). BALLS, W. LAWRENCE ... "Studies of Egyptian Cotton." Yearbook of the Khedival Agricultural Society. 1906.

(8). BALLS, W. LAWRENCE ... "Mendelian Studies of Egyptian Cotton. *Journal of Agricultural Science*, Vol. II, July 1908, p. 347.

(9). LEAKE, H. M. ... "Studies in the Experimental Breeding of Indian Cottons." *Journal of the Asiatic Society of Bengal.* New Series, Vol. IV, 1908, No. 1.

(10). DARWIN, C. ... Variation in Animals and Plants under Domestication. Ed. 1868. Vol. II.

(11). BATESON, W., AND SAUNDERS, MISS E. R. ... Report to the Evolution Committee of the Royal Society. I.

(12). BATESON, W., SAUNDERS, MISS E. R., AND PUNNETT, R. C. Reports to the Evolution Committee of the Royal Society, II. & III. 1905 & 1906.

(13). SHULL ... "On Mendelian Inheritance of Sunflowers." *Botanical Gazette.* Vol. XLV, No. 2, Feb. 1908, p. 106.

(14). CORRENS, C ... Weitere Beitrage zur Kenntniss der dominerenden Merkmaale und der Mosaik-bildung der "Bastarde" Ber. Dentsch. Bot. Gesells. 21 : s. 195—201, 1903 quoted by Shull (13).

DESCRIPTION OF FIGURES.

Figs. 1 to 10 are from tracings made of normal leaves.

Fig. 1. "Jowari" (G. herbaceum).
Fig. 2. „ „
Fig. 3. "Northerns" „
Fig. 4. Jari (G. neglectum).
Fig. 5. Cross Jari × Jowari (No. 2 of Table II).
Fig. 6. „ Jowari × Jari (No. 3 „ II).
Fig. 7. Leaves on young and old stems of the same cross as No. 6.
Fig. 8. Cross Northerns × Jari (No. 5 of Table II).
Fig. 9. „ Jari × Northerns (No. 6 „ II).
Fig. 10. Abnormal leaves in the second generation hybrid of Jowari × Jari.

Figs. 11 to 18 are from photographs 15, 16 and 17 of living plants, the others of herbarium material.

Fig. 11. Young plant of Jari.
Fig. 12. From an older plant of Jari.
Fig. 13. Northerns.
Fig. 14. Cross Bilai × Jari.
Fig. 15. A row of Jowari × Jari hybrid (No. 3). Showing the similarity of the plants in height and in their leaves, Some of the flowers have been covered by paper bags and labelled. Behind and parallel to it, is a row of cross No. 5.—(Northerns × Jari), and behind these at right angles a row of pure Jari, and two young tree cottons nearer to the right.
Fig. 16. Part of plant No. 2321. The lower branches ascend the upper are stiffly at right angles (the middle one on the left hand side was broken), the characteristic "neglectum" leaves and the opening of the bolls are clearly shown.
Fig. 17. Part of plant No. 2188, the branches are less stiff, and the leaves quite different.
Fig. 18. Part of plant No. 2282 (herbarium material).
Fig. 19. „ „ 2617 („ „).

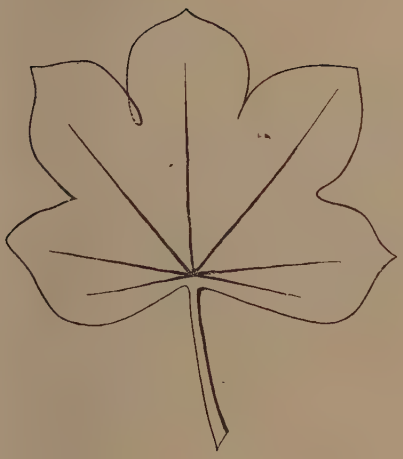

FIG. 1.

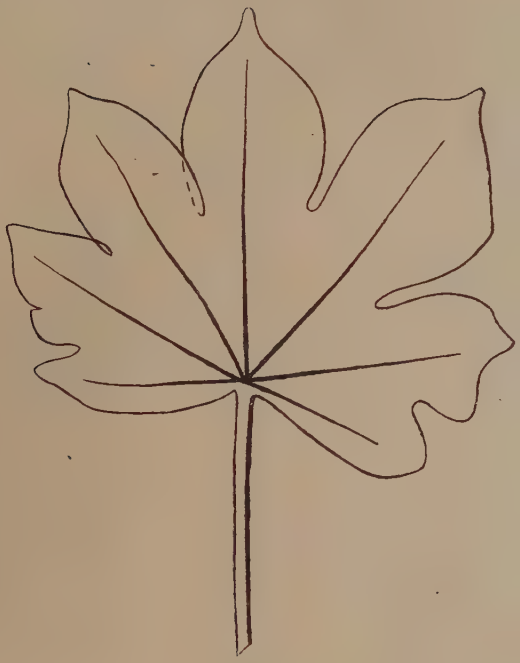

FIG. 2.

FIG. 3.

FIG. 4.

Fig. 5.

Fig. 6.

Fig. 7.

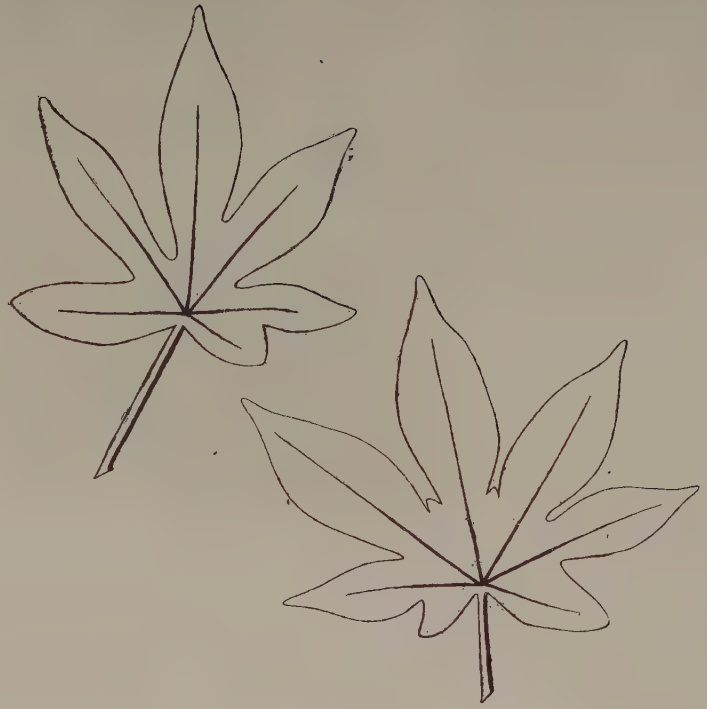

Fig. 8.

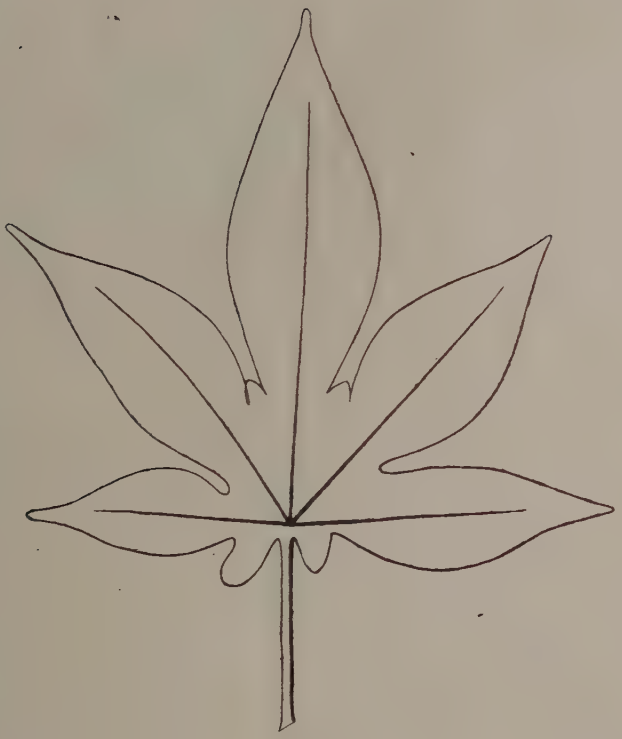

Fig. 9.

FIG. 11.

FIG. 12.

FIG. 13.

FIG. 14.

Fig. 15.

FIG. 16.

FIG. 17.

FIG. 18.

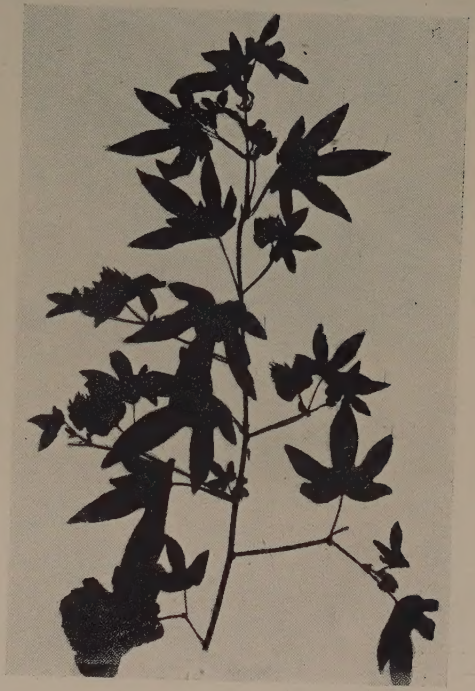

FIG. 19.